Wavelength Shifting Fiber

Carl Bromberg
Michigan State University

Director's Review of NOνA
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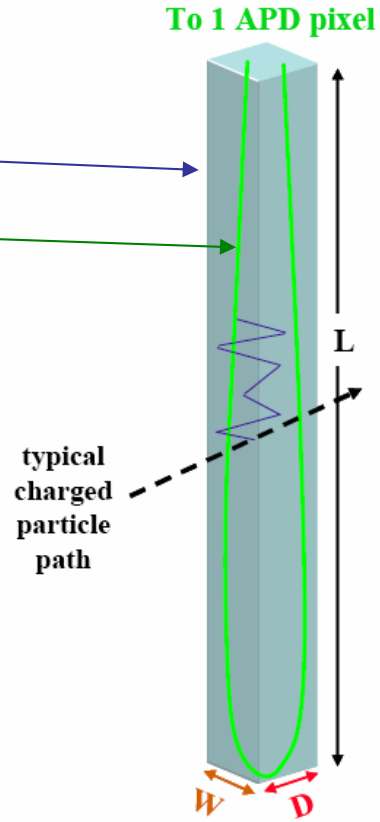
WLS Fiber for NOvA

- NOvA signal generation
  - Liquid scintillator in a highly reflective cell
  - Wavelength shifting (WLS) fiber loop
  - Avalanche photodiode (APD)
- WLS fiber features
  - Immersed in liquid scintillator
  - Only long-λ light from U-bend reaches APD
  - APD QE > 80% at long wavelengths
  - U-bend with small diameter ~70 mm
- Fiber R&D
  - Obtain firm quotes for high quality fiber
  - p.e. yields, fiber survival and optimization
  - Develop QA tools



Fiber price

- Two day visit to Kuraray
  - NOvA management visitors: C. Bromberg, B. Choudhary, and R. Ray
  - Met by Y. Shiomi (sales representative and guide) in Tokyo
  - Train to west coast of Japan, to Nakajo fiber production facility
  - O. Shinji (Special Staff), S. Takyama (QC section), S. Gotanda (plant GM)
  - Tour included inspection of entire production process (mostly proprietary)
  - Meet in Tokyo with K. Kimura (Manager) & H. Muroi (Section Manager)
  - Commodity, transportation, and exchange rate protections are in contract
- Current (final) quote:

Diameter	Quantity: 18,000 km	22,000 km
0.8mm	$0.75/m	$0.72/m
0.7mm	$0.63/m	$0.60/m

  - For larger quantity 0.8mm, price is 16% less than at CD-1 ($0.86/m)
  - FY08-11 delivery, 25% slower rate, same four year period as CD-1
- It is doubtful that any other source will surface

Cost: WBS 1.3/2.3 WLS Fiber

NOvA Project 20 kT

WBS x.3 WLS Fiber	Estimated Cost (FY06 $M)	Contingency Estimate (FY06 $M)	Contingency (%)	Total Project Cost (FY06 $M)
Construction w indirects				
M&S	13.7	3.8	28%	17.5
Labor	0.0	0.0	4%	0.0
Construction total:	**13.7**	**3.8**	**28%**	**17.5**
R&D				
M&S	0.15	0.00	0%	0.15
Labor	0.09	0.00	0%	0.09
R&D total:	**0.24**	**0.00**	**0%**	**0.24**

WLS Fiber Milestones

Nova Project
WBS 2.3 - WLS Fiber
Milestones

Activity ID	Activity Desc.	FY08				FY09				FY10				FY11				FY12				FY1		
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q
2.3 -- Wave-Length-Shifting Fiber																								
2.3.1.1.5	Release purchase orders-near detector	△																						
2.3.1.2.5	Release purchase orders-far detector	△																						
2.3.2.2.1.3	WLS fiber production begins	△																						
2.3.2.2.1.4	WLS fiber production for 5 kt completed					△																		
2.3.2.2.1.5	WLS fiber production for 10 kt completed									△														
2.3.2.2.1.6	WLS fiber production for 15 kt completed													△										
2.3.2.2.1.7	WLS fiber production for 20 kt completed																	△						
2.3.2.2.1.8	WLS fiber production completed (25 kt)(reserved)																	△						

Previous fiber R&D

- Minnesota & Indiana
  - Cosmos liquid scintillator calorimeter prototype, Bicron fiber, no obvious loss (±20%) in 10 years
  - 10 WLS fiber loops in 50% pseudocumine @ 42 °C, no change in transmission over a few months.
  - p.e. yields for muons in NOvA cell, liquid scintillator filled
- Fiber survival tests by Kuraray
  - Fluorinated polymer & acrylic claddings are insoluble in pseudocumine
  - Polystyrene core is soluble, but is protected by two layers of cladding
  - Fibers in 5-20% pseudocumine, 140 days, ~ 15% light loss, no concentration dependence, no 0% control.
  - Nevertheless, Kuraray expects NOvA to take responsibility for fiber survival in liquid scintillator

Current fiber R&D

- 150 m fiber samples distributed to R&D labs in June
  - Baseline Fiber: diameter 0.8 mm, K27 dye @ 200 ppm
  - MINOS optimized K27 dye at 200 ppm for fibers with 1.2 mm diameter, 8 m long, with a PMT photodetector
  - NOvA fiber is 0.7-0.8 mm diameter, 16 m long, APD photodetector
  - Obtained fiber with 0.6, 0.7, 0.8 mm, each with K27 dye at 150, 250, 300 ppm
- Primary R&D responsibilities (poaching OK)
  - Verify p.e. yields in NOvA liquid scintillator (CalTech: J. Trevor)
  - Fiber torture tests to determine damage limits; is 0.7 mm OK? (UCLA: K. Lee)
  - Light yield & attenuation vs wavelength (UT Dallas: E. Fenyves)
  - Measure relative light yields in simulated NOvA cell & develop QA tools for production (MSU: CB, R. Richards, B. Page)
- For prospective Italian collaborators, samples sent to Ferrara
- 5 km of baseline fiber to Minnesota for module factory R&D
- R&D results available this FY

Module assembly and lamination

- At MSU, Ron Richards and CB have been investigating alternatives to Epoxy adhesives for critical NOvA assembly steps:
  - Joints and seals of endplate and fiber manifold to make 53 ft long PVC modules
  - Laminations of 372 PVC modules into 31 layer blocks, weighing 150 Tons
- Ashland Chemical Corp's Emabond process
  - RF absorbing plastic "gasket" melts to WELD seals and joints between plastic parts.
  - Impressive list of existing commercial applications (high pressures, fluids from gasoline to blood, high temperatures, food containers, automotive body parts, ...)
  - Heat-cool cycle < 1 min., NO particulates, inert, mechanically stable, ...
  - Proof of principle tests have established viability of technique for NOvA
- Ashland met with CB and NOvA engineeers Richards, Chase, Pushka, & Guarino
  - Proposals are being prepared by Ashland for
    - Prototyping endplate and welding machine for recently produced 16-cell PVC extrusion
    - Tests of PVC lamination strength in shear, peel, tension, ...
    - Tests of 4 layer laminations of 16-cell extrusions
    - Tests of joining two 16-cell extrusions into 32-cell units
    - Design and prototyping of manifold adaptor plate
    - Preliminary assembly at Ashland plant of modules for the Integration Prototype